FOSSIL CLASSIFICATION AND MORPHOLOGY

Exercise 10

Classification of fossil plants and animals is called **taxonomy.** The basis for taxonomy is similarity of morphology and shape, and phylogenetic relationships. In practice, all fossils are assigned two-part names, following what is called the binomial system. The first part of the name is the **generic** name; the second is the **specific** name. Occasionally a third or even a fourth part is used to show combinations of subgenera or subspecies. Ordinarily, however, only genus and species names are used. The Roman alphabet is used for all names in texts of any language. Conventionally, names are derived from Latin or Greek roots. The basis for subdivision and classification of organisms is the species. **Species** are defined as groups of organisms that normally interbreed and produce fertile offspring. This definition, although usable for neontologists or taxonomists of modern species, is not usable for the study of fossils in paleontology where the basis of classification is in fact morphology or similarity in form. Thus, we only infer in paleontology that morphological species were in fact interbreeding groups of organisms during their lifetime.

In table 10–1, the taxonomic hierarchies of a man and a dog are used as examples in the classification from kingdom to the individual. Generic, subgeneric, specific, and subspecific names are italicized. Many of the scientific names are used as common words or in general ways with English plurals and nonitalicized form. Table 10–2 provides an abbreviated classification of animals and plants.

Table 10–1 Hierarchy of Taxonomy

Kingdom	Animalia	Animalia
Phylum	Vertebrata	Vertebrata
Class	Mammalia	Mammalia
Order	Carnivora	Primates
Family	Canidae	Hominidae
Genus	*Canis*	*Homo*
Species	*familiaris*	*sapiens*
Individual	Rover	John Brown

Protozoans

Protozoans are unicellular organisms that range in size from microscopic to several millimeters in diameter. Protozoans live in marine environments as plankton and benthos, in fresh water, and as parasites in many living organisms. These small single cells perform all of the living functions necessary for complete life cycles.

In spite of their size and relative simplicity, protozoans display a great variety of shapes and forms, and species are differentiated on that basis. Of the great variety of protozoans, only the two groups that possess hard parts are important as fossils (fig. 10.1). The first group, called foraminifera, are extremely abundant and are important in stratigraphy as time indicators. The foraminifera have shells or tests composed of calcium carbonate or of fine grains of minerals or rocks cemented together. The tests of forams are composed of chambers assembled in a variety of ways and patterns. One group of foraminifera, called fusulinids, built shells with about the same size and shape as grains of wheat or rice.

The second group of protozoans are radiolarians, a group that is abundant in modern seas and that has tests composed of concentric spheres or helmet-shaped, spiny structures of silica. Protozoans are known from rocks as old as Cambrian and even perhaps Precambrian, and they range to the Recent. Both foraminifera and radiolarians are abundant in the modern seas where their tests accumulate to form radiolarian and foraminiferal oozes. Fusulinids are used as stratigraphic time indicators in

Table 10–2 Abbreviated Classification of Animals and Plants (as used in paleontology)

Animal Kingdom		
Phylum	PROTOZOA Single cells, or groups of cells, generally microscopic foraminifers, radiolarians, fusulinids	
Phylum	PORIFERA Sponges and stromatoporoids	
Phylum	COELENTERATA Corals—tetracorals, hexacorals and tabulate corals	
Phylum	BRYOZOA Moss animals—small colonial animals	
Phylum	BRACHIOPODA Bivalved invertebrates with unequal dorsal and ventral valves	
Phylum	ECHINODERMATA Animals generally with five-fold radial symmetry, starfish, sand dollars, echinoids, sea lilies or crinoids, blastoids, cystoids	
Phylum	MOLLUSCA Bivalves (Pelecypods)—clam, oyster Gastropods—snail, slug Cephalopods—squid, octopus, nautiloid, ammonoid	
Phylum	ANNELIDA Segmented worms Scolecondonts	
Phylum	ARTHROPODA Invertebrate animals with jointed legs, insects, lobsters, crabs, trilobites, eurypterids	
Phylum	Hemichordata—Graptolites	
Phylum	Unknown—Conodonts	
Phylum	VERTEBRATA Animals with notochords and articulated backbones Pisces (fish) Amphibians Reptiles—dinosaurs, ichthyosaurs, plesiosaurs, mosasaurs Aves (birds) Mammals—warm-blooded animals, including man	
Plant Kingdom		
Division Cyanophyta		blue-green algae
Division Chlorophyta		green algae
Division Phaeophyta		brown algae
Division Rhodophyta		red algae
Division Bryophyta		liverworts, hornworts, mosses
Division Psilophyta		psilophytes
Division Lycopodophyta		club mosses
Division Arthrophyta		horsetails
Division Pterophyta		ferns
Division Pteridospermophyta		seed ferns
Division Cycadophyta		cycads
Division Ginkophyta		ginkgos
Division Coniferphyta		conifers
Division Anthophyta		flowering plants
Class Dicotyledonae		dicots
Class Monocotyledonae		monocots

Carboniferous and Permian rocks where they are abundant; other small foraminifera are used in the dating and correlation of Cretaceous and Tertiary rocks. Radiolaria are used as stratigraphic indicators for deep marine sediments. Because of their small size, protozoans require identification and study with a microscope, but because of their small size they can be recovered in cuttings from drill holes of oil wells and are one of the most common and valuable fossils for stratigraphic studies in late Mesozoic and Cenozoic rocks.

Porifera

Porifera, or sponges, are simple multicellular animals that live attached to the substrate (figs. 10.2 and 10.3A). A sponge may be thought of as a vase-shaped animal. Its body walls are penetrated by a series of canals of varying degrees of complexity. Microscopic food particles are removed from currents of water that pass through the canal system of the sponge. Most sponges are marine but some occur in fresh water. The sponge is held more or less rigid by an internal stiffening skeleton of fibers of spongin or spicules made of calcium carbonate or silicon dioxide. The commercial sponge is the flexible skeleton (spongin) of a modern marine sponge from which all of the once-living protoplasm has been removed.

Because of the nature of the body of the sponge, complete animals are rarely preserved as fossils. The most common fossil remains are the individual minute spicules of silica or calcium carbonate that provided support for the flesh. The most complete fossil sponges are of groups where the skeleton was solidly fused during life. These sponges appear as conical, spherical, and platterlike fossils that are perforated by numerous small canals.

Another group of sponges that are important as fossils are the stromatoporoids (fig. 10.3A). They were a colonial group of organisms that secreted a calcareous laminated skeleton. These laminated colonial skeletal structures resemble heads of cabbage or flat-lying sheets. Other more unusual stromatoporoids formed twiglike structures with a dendritic or branching mode of growth. Stomatoporoids are found in rocks ranging in age from Cambrian to Cretaceous and are quantitatively important in rocks of Ordovician and Devonian ages.

Phylum Coelenterata

Within the phylum Coelenterata, two groups are important as fossils. The first group, the corals, are among the most abundant fossils in sedimentary rocks, and are typically found as either "horn corals," the skeletal remains of a single organism (fig. 10.3B), or as a group of individual skeletons cemented together to form a colony (fig. 10.3 C–D). Solitary corals have a pit in which the animal was attached in the top, broad part of the calcareous "horn." The "horn" functioned as an external skeleton and was built in daily increments by the organism.

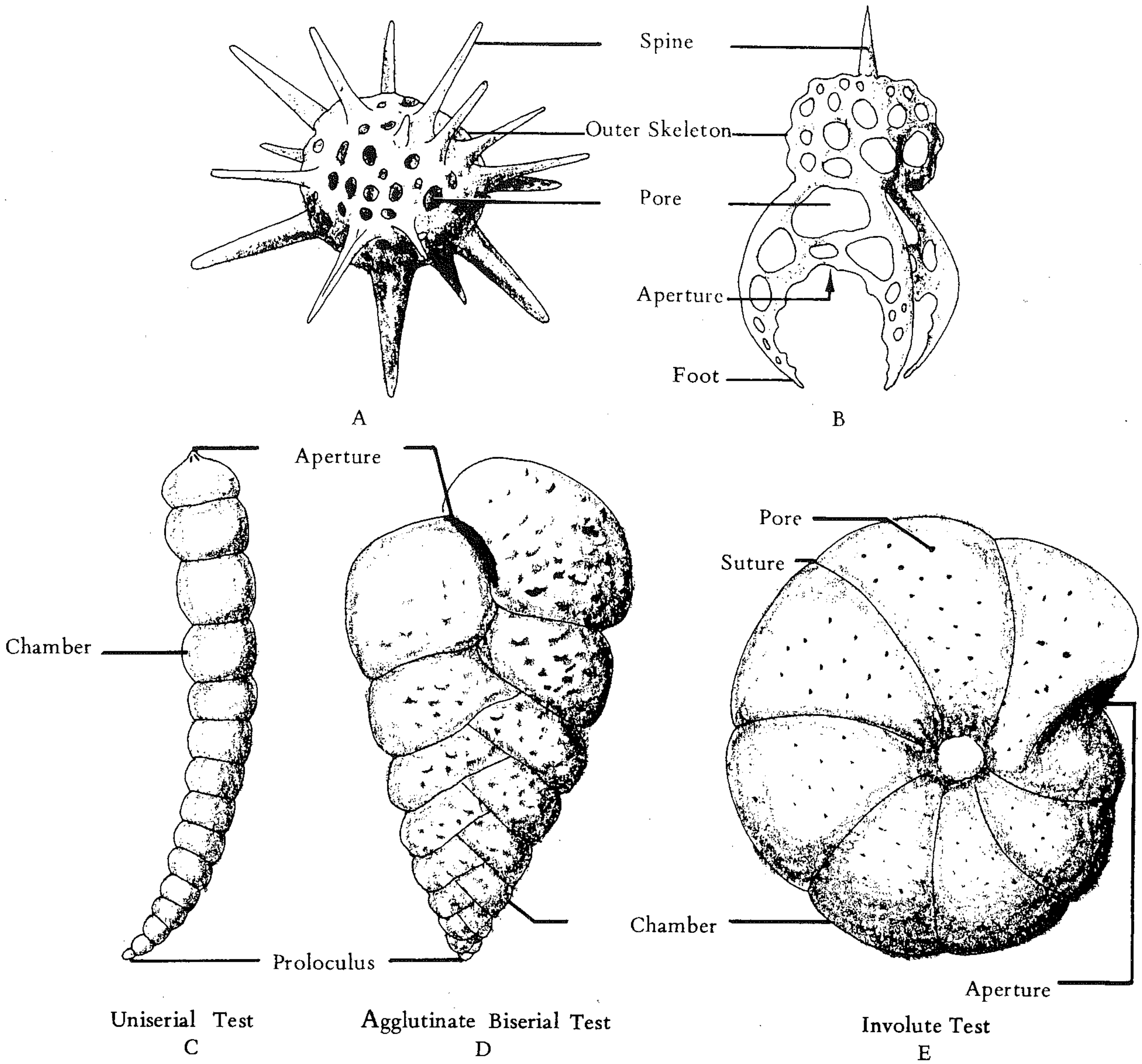

Figure 10.1 Morphology of radiolarians and foraminifera.
A–B, radiolarians (×100); **C–E,** foraminifera (×100).

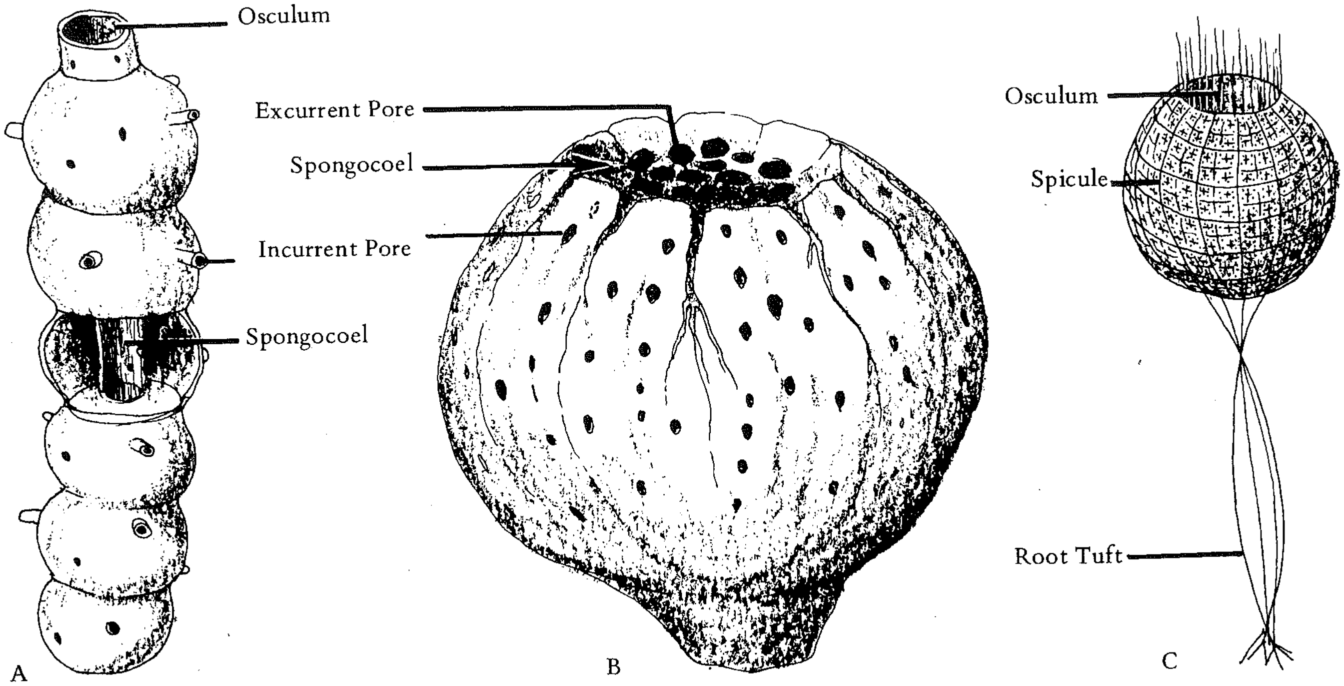

Figure 10.2 Morphology of fossil sponges. **A,** calcareous sponge; **B,** lithistid sponge; **C,** hexactinellid sponge.

Corals first appear in Ordovician rocks, have continued as a major group through the Paleozoic, Mesozoic, and Cenozoic, and are common in modern seas. Corals form reefs in modern seas and inhabit the shallow areas of the ocean near the equator, and it is presumed that they did so in the past.

Phylum Bryozoa

Bryozoans, the moss animals, are small aquatic organisms that secrete colonial calcareous external skeletons and are common as fossils (fig. 10.4). Most bryozoans were marine but a few freshwater forms are also known. They are more advanced than corals and have a nervous system and a U-shaped digestive tract. The colonial organisms lived in the minute pores or tubes that perforate the stony skeletal structure. Fossil bryozoans resemble bits of lace or small twiglike structures, often encrusting other organisms or fossils. They are usually preserved lying parallel to the bedding planes of the enclosing layers. Bryozoa are found in rocks that range in age from the Cambrian to the Recent and are particularly abundant in rocks of Mississippian to Permian ages. Because of their small size, relatively slow evolution, and difficulty of identification, fossil bryozoans have not been used extensively in stratigraphic determinations.

Brachiopods

Brachiopods are marine invertebrates that were much more abundant in the seas of the Paleozoic Era than they are today (fig. 10.5). They range in size from less than an inch to approximately 6 inches at their broadest point. Their calcareous or chitinophosphatic shell consists of two unequal valves that are symmetrical when divided into lateral halves. This shell shape distinguishes the brachiopods from the bivalves (clams, etc.), which are equivalved with right and left valves that are essentially mirror images of each other (fig. 10.6). They are among the most abundant fossil types found in rocks of the Paleozoic Era. Their shells are preserved in nearly every type of sedimentary rock. Because of their abundance, their great variety in shell form, and ease of identification, brachiopods are extremely useful as time and ecologic indicators in stratigraphic studies.

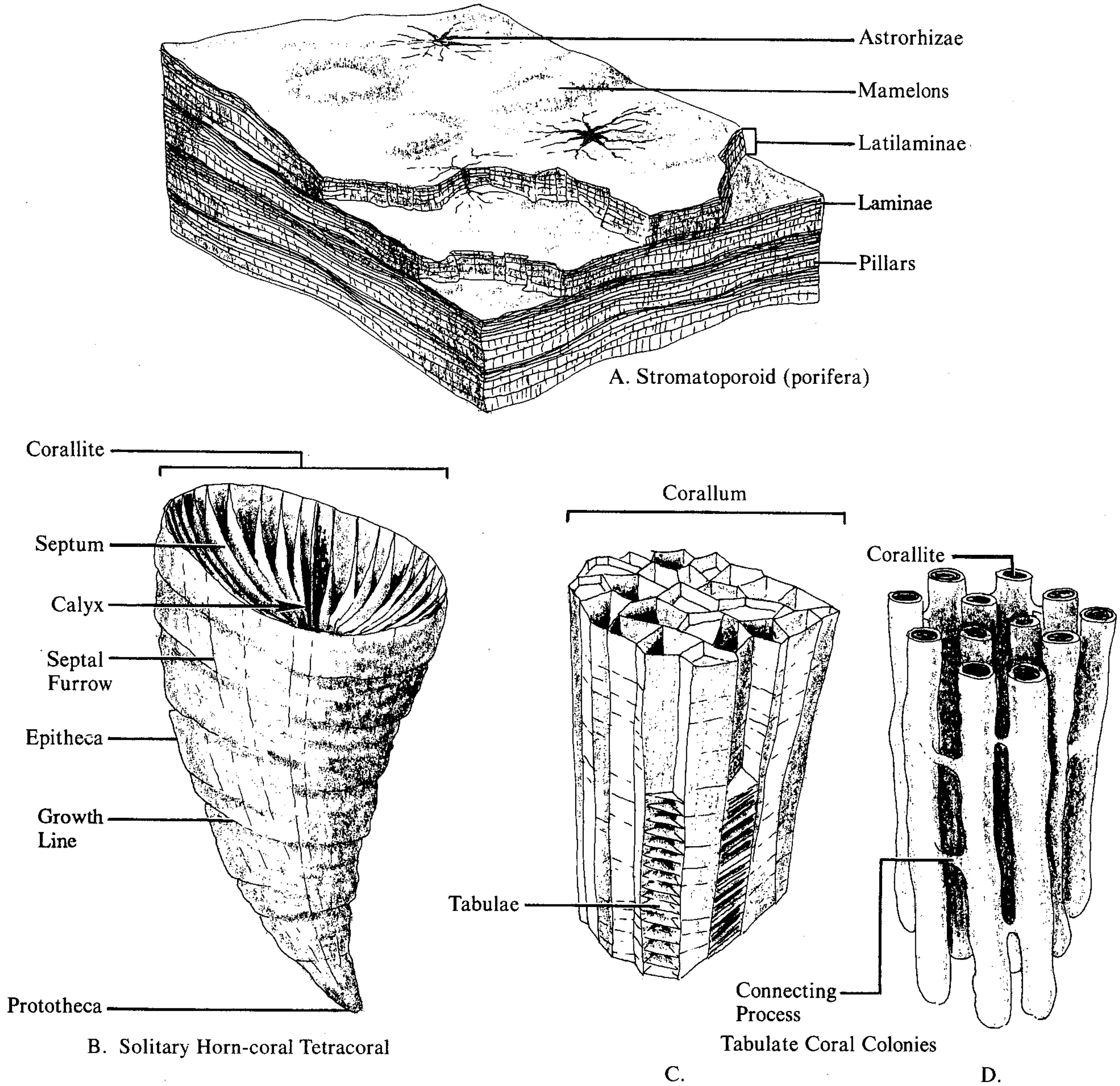

Figure 10.3 Morphology of porifera **(A)** and coelenterates **(B–D). A,** stromatoporoid; **B,** tetracoral; **C–D,** colonial tabulate corals.

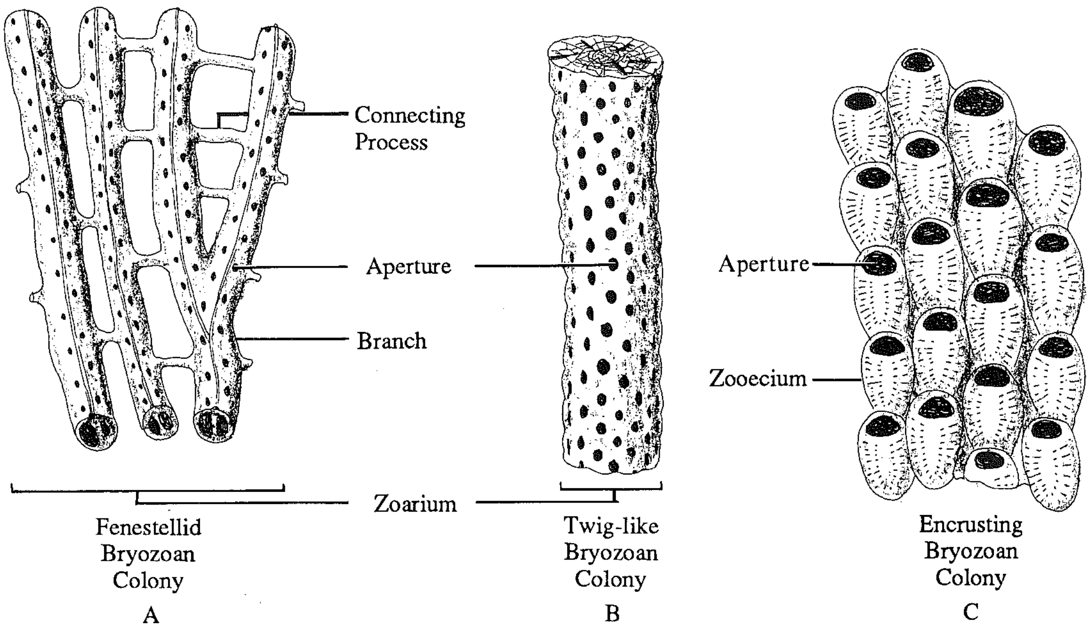

Figure 10.4 Morphology of bryozoans. **A,** fenestellid type (×3); **B,** twiglike type (×5); **C,** encrusting cheilostome type (×5).

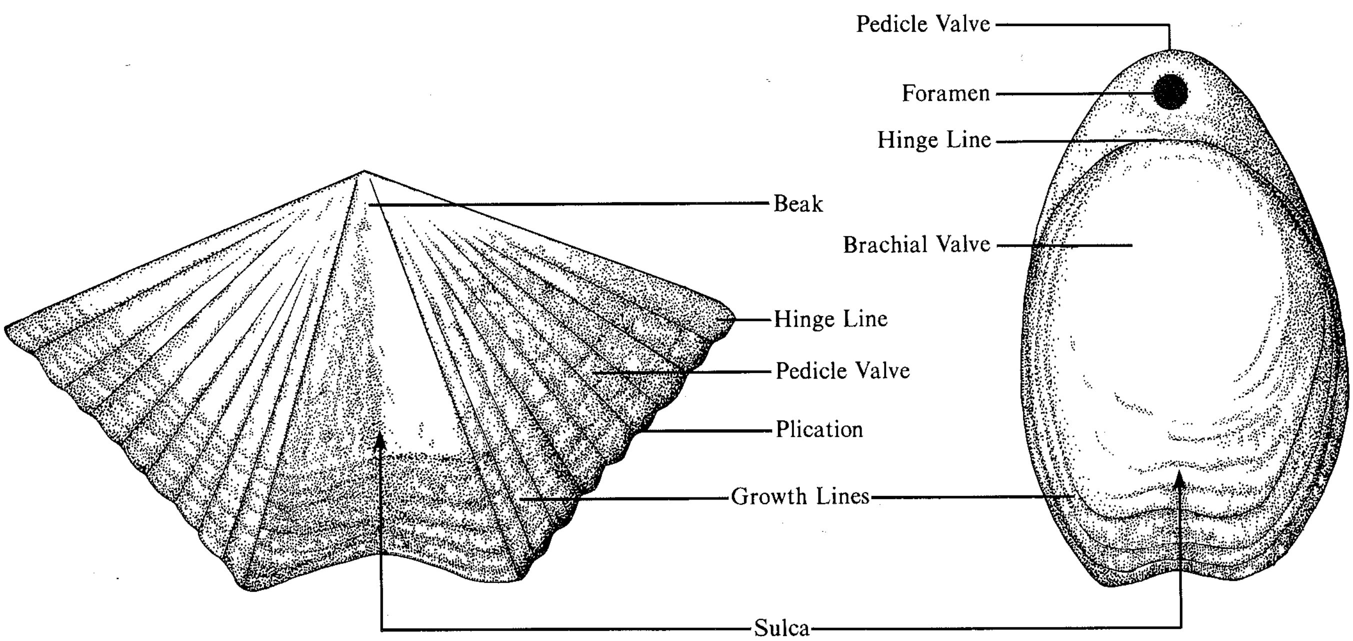

Figure 10.5 Morphology of brachiopods, based upon two common types.

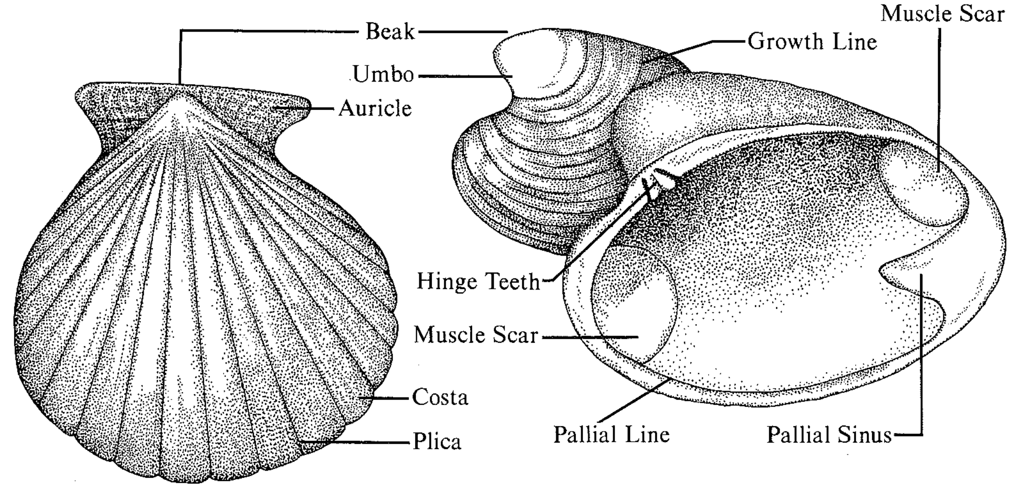

Figure 10.6 Morphology of bivalves. **A,** scallop; **B,** clam.

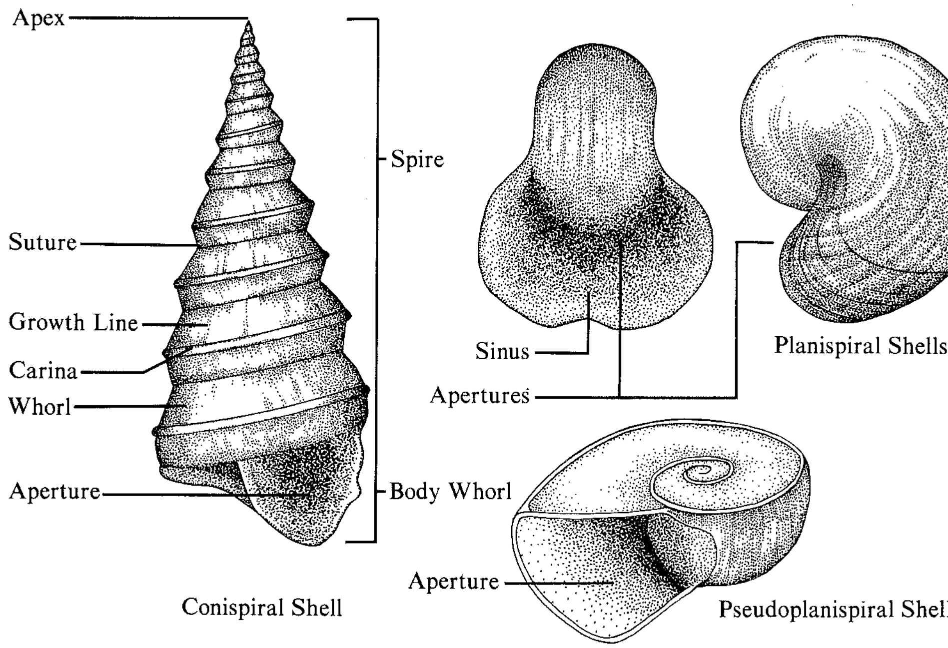

Figure 10.7 Morphology of gastropods, showing three common conch shapes.

Mollusca

The phylum Mollusca includes animals that are zoologically similar, but superficially different because of the great diversity in the shapes of their shells. Included in the phylum are the bivalves (clams, scallops, and oysters), gastropods (snails, slugs, pteropods) (fig. 10.7), cephalopods (*Nautilus,* squid, octopus, and cuttle fish) (fig. 10.8), and other less common forms such as the chitons and scaphopods.

As fossils, mollusks are common in marine and nonmarine rocks from the Cambrian to the Recent. Their calcareous shells are valuable indicators of time and ecology. One group of cephalopods, the ammonoids (fig. 10.8A), have complexly chambered shells and are used as a worldwide standard of reference in biostratigraphy from the Devonian through the Cretaceous. Mollusks have adapted at present to many ecologic niches from deep ocean benthonic environments to air-breathing existence on mountain peaks at 18,000 feet above sea level.

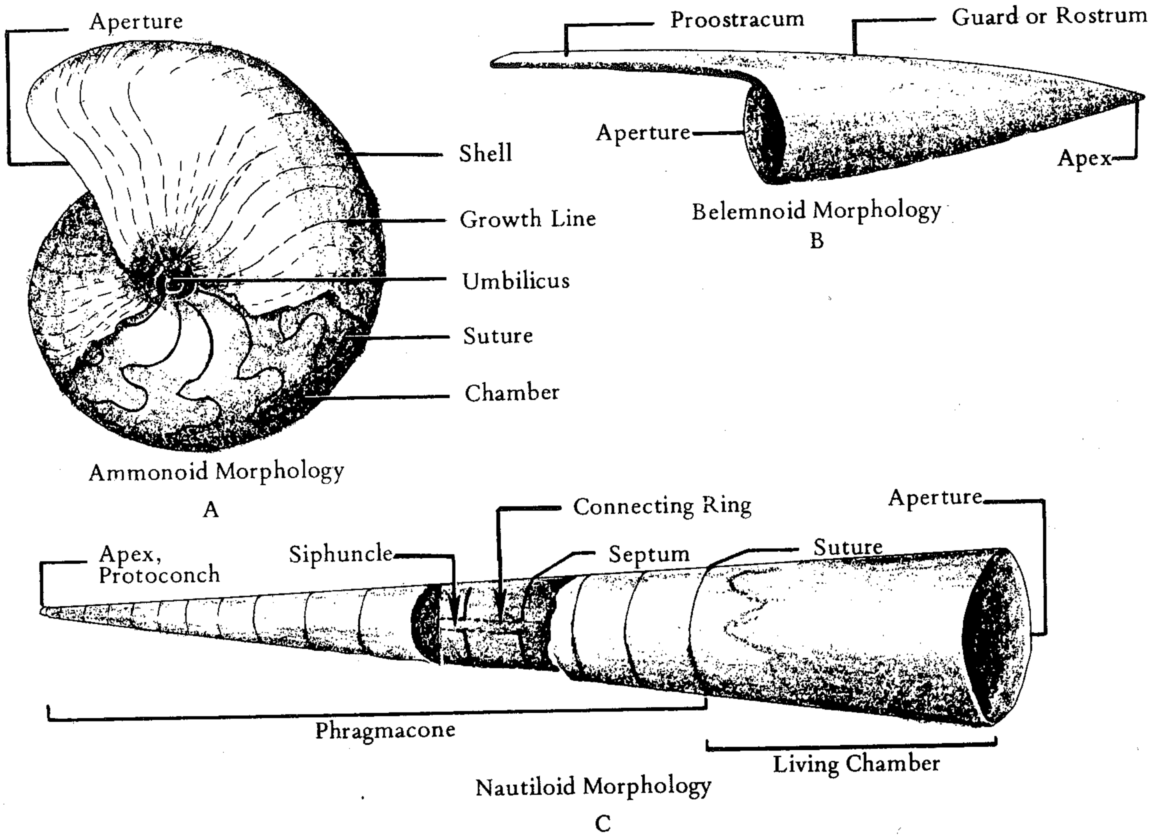

Figure 10.8 Morphology of cephalopods. **A,** ammonoid; **B,** belemnite; **C,** nautiloid.

Arthropods

The arthropods are characterized by their chitinoid, segmented exoskeleton, or carapace. This group includes insects, crustaceans (crabs, lobsters, etc.), chelicerates (spiders, etc.), myriapods (centipedes and millipedes), and trilobites. Of these groups, only the trilobites and a type of crustacean, the ostracodes, are common as fossils (fig. 10.9). Trilobites especially are abundant fossils in Cambrian, Ordovician, and Silurian rocks. Because arthropods shed their chitinous exoskeletons along joints, their fossil remains often consist of disarticulated heads, tails, or body segments.

Trilobites and ostracodes both are important fossils as time indicators. Trilobites lived from the Cambrian through the Permian, and the ostracodes lived from the Cambrian to the Recent. Trilobites are particularly useful guide fossils for Cambrian and Ordovician rocks, and ostracodes have been most used in rocks from the Ordovician, Silurian, Devonian, and Cenozoic.

Echinoderms

Echinoderms, or "spiny-skinned animals," are exclusively marine organisms and include the modern starfish, brittle stars, sand dollars, sea urchins, sea cucumbers, and sea lilies. This group of organisms was even much more common in the geologic past than it is at present. Echinoderms typically display five-fold radial symmetry. Their skeletons are formed of calcite plates, which are secreted inside an outer tissue layer, and form an external skeletal covering. Echinoderms that are important as fossils include crinoids, blastoids, cystoids, and echinoids (fig. 10.10). Echinoids are found throughout the entire geologic column from Lower Cambrian to Recent; however, they are more typical of Carboniferous, Permian, and Tertiary deposits. Blastoids, cystoids, and crinoids all reached high points of evolution during the Paleozoic. Many limestones of Mississippian age contain abundant crinoid stem fragments, sometimes making up the bulk of the rock mass.

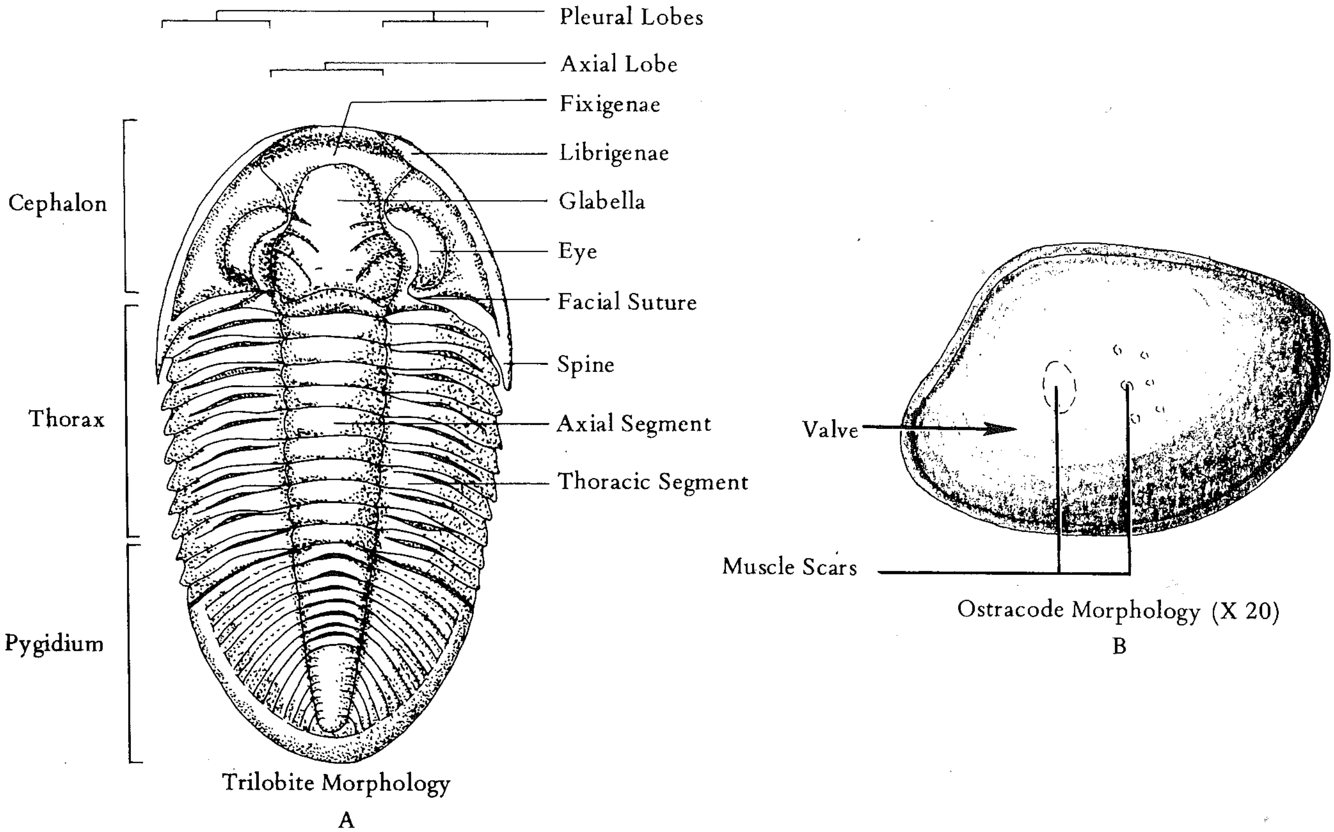

Figure 10.9 Morphology of two common fossil arthropods. **A,** trilobite; **B,** ostracode.

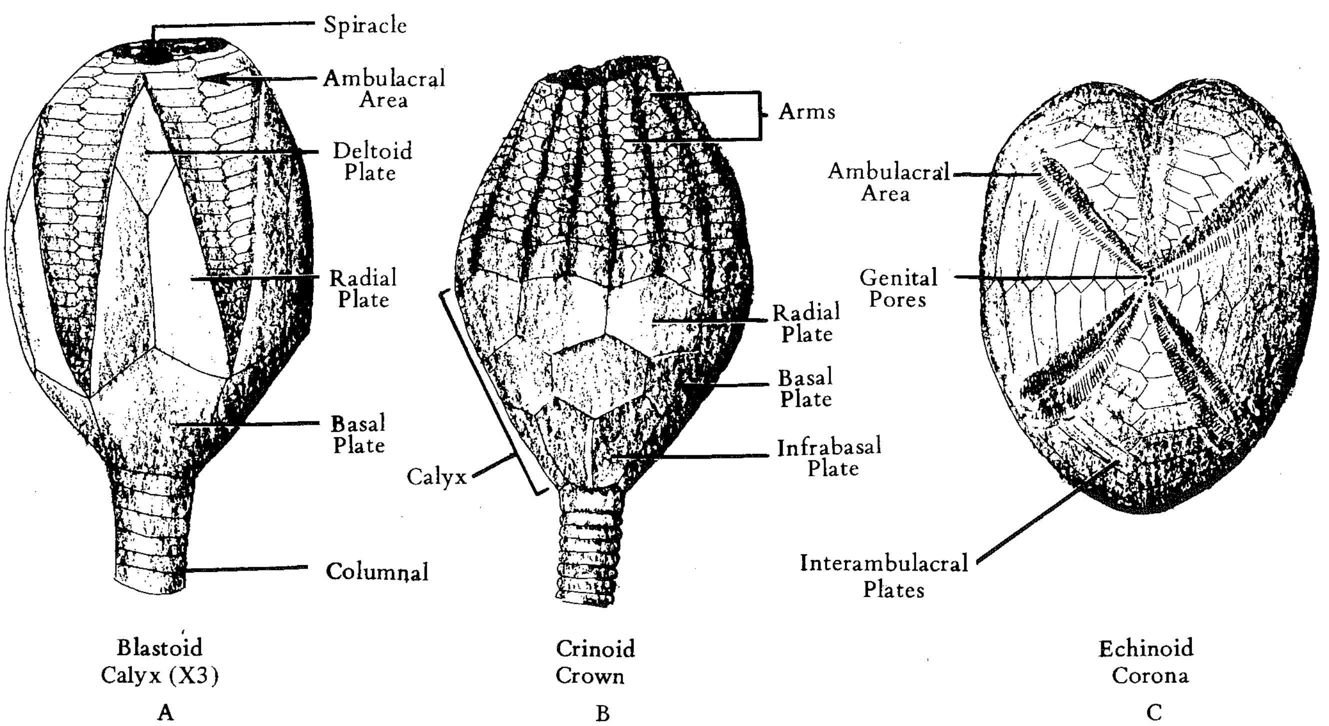

Figure 10.10 Morphology of three common fossil echinoderms. **A,** blastoid (×3); **B,** crinoid; **C,** irregular echinoid.

Graptolites

Graptolites are a group of extinct colonial organisms whose proteinacious, saw bladelike remains appear superficially similar to pencil marks on the surface of rocks, thus their name, which means "writing on rocks." They are typically small fossils; colonies ordinarily measure a few centimeters across. The individuals of a colony are nearly microscopic in size (fig. 10.11).

Graptolites are most important as time indicators during the Ordovician, Silurian, and Devonian periods. The Ordovician Period is often called the Age of Graptolites. Some graptolites lived into the Mississippian, but the group is not useful for time determination after the lower part of the Devonian.

Conodonts

Conodonts are an extinct group of phosphatic microfossils whose zoological affinities have only recently been established as vertebrate (fig. 10.12). Most conodonts are less than one millimeter in size and are medium to dark brown in color. They can be found in almost all kinds of sedimentary rock from the Cambrian to the Triassic. In the Ordovician, Devonian, Mississippian, and Triassic periods, they are the most useful fossils available for intercontinental correlation because of their widespread occurrence, abundance, and highly predictable evolutionary patterns.

Procedure

The information presented in this exercise is provided to acquaint the student with the important morphologic features of the major fossil groups. After studying actual specimens provided by your instructor, identify the morphology that is preserved on your study materials. Indicate, by marking on the diagrams, those morphologic features you have actually observed in your study. It is common for a single specimen to display some morphologic elements, while others are not preserved. Observe several specimens of each type of fossil until you have personally observed all important elements of morphology.

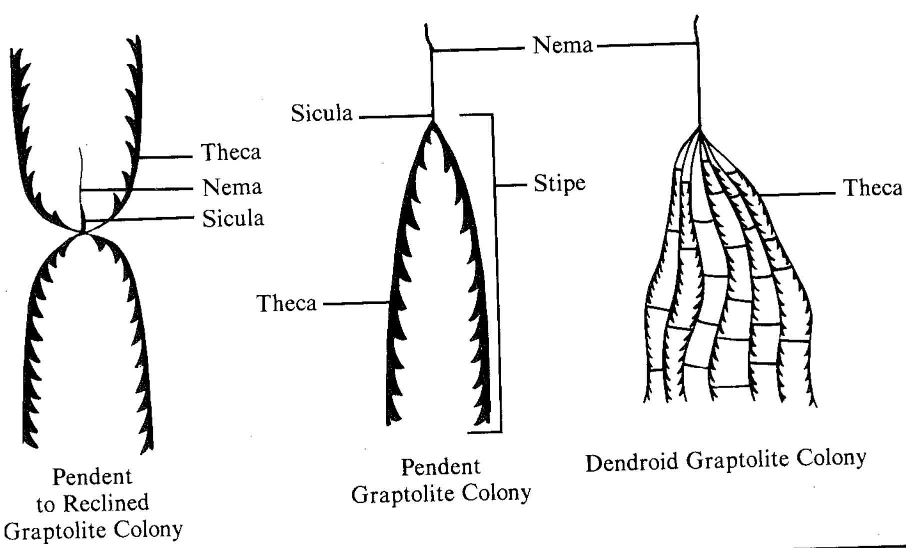

Figure 10.11 Morphology of three common types of graptolites (×2).

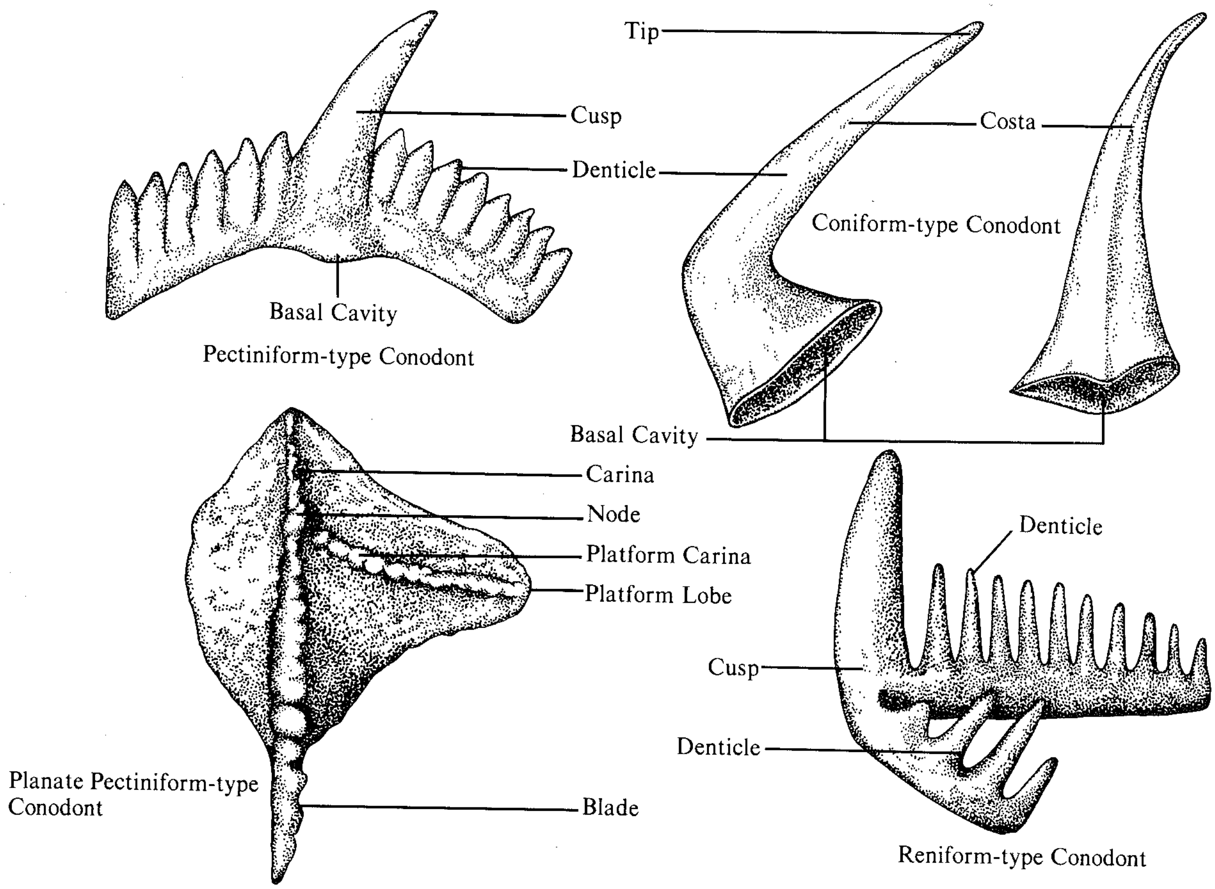

Figure 10.12 Morphology of conodonts, showing parts of four common types (×50).